EFFECTS OF THE INTRODUCTION OF GAS AND WATER PIPES.

Since the use of gas has become so general in our cities as to be considered almost one of the essentials of civilized life, a new source of danger has been introduced. Persons who repudiate the use of lightning rods, because they attract the electricity from the clouds, should reject the introduction of gas, particularly into the upper stories of their dwellings, since the perpendicular pipes must act as the most efficient conductors between the cloud and the earth. We say the most efficient, because they are connected below the ground with a plexus of pipes, in many cases, of miles in extent, the whole of which is rendered by the induction of a large cloud highly negative; and, since this action takes place with as much efficiency through the roof of a house and the chamber floors as it does through the open air, a gas-pipe, therefore, within a house, in proportion to its height, would powerfully attract any discharge from a cloud in its vicinity.

To obviate the danger from this source, the lightning-rod, which rises above the top of the building, should be placed in immediate metallic contact with the plexus of gas-pipe outside the house. If, as is very frequently the case, the rod is made to terminate by simple insertion of a few feet in the dry earth, while the gas-pipe is connected with miles of metallic masses, rendered highly negative by induction, the path of least resistance, or of most intense induction from the cloud to the earth, will be down the rod to some point opposite the gas-pipe, then through the house and down the pipe into the great receiver below. This conclusion, from the theory, is fully borne out by observation. On Friday evening, May 14, 1858, a house in Georgetown, D. C., was struck by lightning, and on Saturday, the next evening, another house was struck in Washington, on Seventeenth street, north of the avenue. The writer carefully examined the conditions and effects in both cases, and found them almost identically the same. The houses were similarly situated, with gable ends north and south, and attached to the west side of each was a smaller back building. The lightning-rod of the house at Georgetown was placed on the southern gable. It terminated above in a single point, and its lower part was inserted into hard ground, through a brick pavement, to the depth of about five feet. The lightning fell upon the point, which it melted, passed down the rod until it came to the level of the eaves, thence leaving the conductor, it passed horizontally along the wet clapboards to the southwest eave or corner of the house, thence down a tinned iron spout to the tin gutter under the roof of the back building, and thus it pierced the wall of the house opposite the point on the outside of the back building corresponding to the position of a gas-pipe in the interior, after which no further effects of it could be observed. A small portion of the charge, however, diverged to a second gas-pipe in an adjoining room. The back building was of wood, and the passage of the charge appeared to be facilitated by a large nail. The discharge was marked throughout its course by the effects it produced: 1st, the point of the rod was melted; 2d, a glass insulating cylinder, through which the upper part of the rod passed, was broken in pieces; 3d, the horizontal clapboard extending from the rod to the eave was splintered; 4th, the tin of the gutters and spout exhibited signs of fusion; 5th, the plaster was broken around the hole through which the charge entered the house.



The lightning rod of the house which was struck in Washington was placed on the north gable; the electricity left the conductor at the apex of the roof, descended along the angle of the coping and the roof, which was lined with tin, to the northwest eave of the main building, thence southward along a tin gutter until it met a perpendicular tin spout, which conducted it to a point on the outside of the back building, corresponding to a gas-pipe within; it then pierced a nine-inch brick wall and struck the gas-pipe, which was embedded in the wall of the main building, at the distance of 15 inches horizontally north of the hole which it pierced in entering the interior. A lady was sitting with her back toward the point where the discharge entered the gas-pipe, at the distance of 18 inches, and, though she was somewhat stunned at the time, and perceived a ringing sensation in her ears for sometime after, she received no permanent injury. At the last meeting of the American Association, Professor Benjamin Silliman, jr., described two instances of a similar character, in which the discharge from the cloud struck twice, in different years, the lightning rod of the steeple of a church in New Haven, left the conductor and entered the building, to precipitate itself on the gas-pipes of the interior. The remarkable fact was stated, in connection with this occurrence, that the joinings of the gas-mains, under the street on the outside of the building, were loosened, apparently by the mechanical effect of the discharge, and the company was obliged to take them up and repair the damage, to prevent the loss of gas. An occurrence of this kind might, perhaps, lead the proprietors of gas-works to object to the proposition of connecting the end of the rod with these mains; but they should recollect that, if means be not furnished to prevent the danger consequent upon the use of gas, a less amount of the article will be consumed; and, furthermore, that giving more efficiency to the inductive action of the rod, on the cloud, by the connection we have proposed, the tendency to a discharge will be lessened; and, finally, that, if the connection be not formed, the discharge from the cloud will itself find the main through the gas-pipes within the house.

There is another source of danger, of a similar character, in cities supplied with water from an aqueduct; the pipes in different stories of the building, connected with the water-mains which underlie the city, are in most intimate connection with the earth, subject to a powerful induction from the cloud above, and therefore will attract any discharge which may be passing in their vicinity, or even determine the point at which the rupture of the stratum of air between the cloud and the house shall take place. In this case the lightning-rod should also be connected on the outside of the building with the pipes under ground, in order that the induction through the rod should be as perfect as possible, and that the consequent attraction may confine the charge, and transmit it entirely to the large mains, and from them to the earth. Houses are sometimes supplied with water from the roof, collected in tanks in the loft, whence it is distributed by pipes to different parts of the building. This arrangement also tends to invite the lightning in proportion to the perpendicular elevation of this system of conductors. The lower ends of these are not usually in very intimate connection with the earth, and therefore a less powerful induction takes place than in the other instances we have mentioned. They should be placed, however, as in the preceding case, in good metallic connection, on the outside of the house, with the lightning-rod. The same remark applies to steam and hot-water pipes used for heating large buildings.

The different sides of a building are not all equally exposed to accident from lightning. Thunder clouds in this latitude approach us from the southwest, and hence the part of the house which faces this direction is not only more exposed to the fury of the storm, but also to the effects of the electrical discharge. The position, then, of the lightning-rod on this account is not to be neglected. The soot which lines a chimney is a good conductor, and hence the discharge not unfrequently passes into the house along the interior surface of this opening. But there is another circumstance which renders the chimney still more liable to be struck, namely: the column of heated air and smoke which ascends from it into the atmosphere when there is a fire burning below. These are tolerably good conductors of electricity, and as they may, under some conditions, extend to a considerable height in the atmosphere, they are sufficient to attract the descending discharge and determine its course to the chimney. A rod should therefore be placed on every chimney through which a column of heated air ascends during the season of the occurrence of thunder storms.

Among the many novel propositions which have been favored by Congress, there was one a few years ago connected with results having a bearing on this subject. For the purpose of lighting the public grounds, an appropriation was made to erect a mast eighty feet in length on the top of the dome of the Capitol. This mast was surmounted by a lantern of about six feet in height and of corresponding diameter, containing a large number of gas-burners, and terminated above by a gilded copper ball of about a foot in diameter. After this gigantic apparatus had been erected in defiance of all the principles of architecture and illumination, the author of this report was called upon to give his opinion as to the effect of lightning upon it. The answer given was as follows: Since the simplest method of obtaining electricity from the atmosphere is to elevate a piece of burning tinder on the end of a fishing-rod, the apparatus placed on the dome of the Capitol is a collector of electricity on an immense scale, and therefore it will probably be struck by lightning. As if to verify this prediction, on the occurrence of the first thunder storm, the apparatus received a discharge from the cloud, which fused several holes in the upper part of the ball and indented the surface, but fortunately did no damage to the building. The apparatus was then removed, and the ball deposited in the museum of the Smithsonian Institution as an interesting illustration of the chemical and mechanical effects of a discharge of lightning.



## EFFECTS OF TELEGRAPH WIRES.

In 1846 the Hon. S. D. Ingham, of Pennsylvania, requested the opinion of the American Philosophical Society as so whether security in regard to accidents from lightning is increased or lessened by the erection of telegraph wires, the poles of which are placed by the side of the roads along which persons with horses and carriages are constantly passing. The subject was referred to the author of the present article, from whose report in regard to it the following facts and deductions are given. The wires of a telegraph are liable to be struck by a direct charge from the clouds, and several instances of this kind have been observed. About the 20th of May, 1846, the lightning struck the elevated part of the wire, which is supported on a high mast where the wire crosses the Hackensac river. The fluid passed along the wire each way from the point which received the discharge for several miles, striking off at regular intervals down the supporting poles. At each point where the discharge took place along a pole, a number of sharp explosions were heard in succession, resembling the rapid reports of several rifles. During another storm the wire was struck in two places on the route between New York and Philadelphia. At one of these places twelve poles were struck, and at the other eight. In some instances the lightning has been seen coursing along the wire like a stream of light, and in one case it is described as exploding from the wire in several places, though there were no bodies in the vicinity to attract it from the conductor.

That the wires of the telegraph should be frequently struck is not surprising, when we consider the great length of the conductor, and consequently the many points along the surface of the earth through which it must pass, peculiarly liable to receive the discharge from the heavens. Besides this, from the great length of the conductor, its natural electricity, driven to the further end or ends of the wire, will be removed to a great distance from the point immediately under the cloud, and hence this will be rendered more intensely negative and its attractive power thereby highly increased. It is not, however, probable that the attraction, whatever may be its intensity, of so small a wire as that of the telegraph, can of itself produce an electrical discharge from the heavens, although, if the discharge were started from some other cause, such as the attraction of a large mass of conducting matter in the vicinity, the attraction of the wire might be sufficient to change the direction of the descending bolt and draw it, in whole or in part, to itself. It should also be recollected that, on account of the perfect conduction of the wire, a discharge on any one point of it must affect every other part of the connected line, although the whole may be several hundred miles in length. That the wire should give off a discharge to a number of poles in succession, is a fact that might have been anticipated, since the electricity would, by its self-repulsion, tend to send a portion of itself down the partial conducting pole, while the remaining part, attracted by the wire in advance of itself, rendered negative by induction, would continue its passage along the metal until it met another pole, when a new division of the charge would take place, and so on. The several explosions in succession, heard at the same pole, is explained by the fact that the discharge from the cloud does not generally consist of a single wave of electricity, but of a number of discharges in the same path in rapid succession, so as in some cases to present the appearance of a continuous discharge of a very appreciable duration; and hence, the wire of a telegraph is capable of transmitting an immense quantity of the fluid thus distributed in time over a great length of the conductor.

From the foregoing, in regard to the direct discharge, we think the danger to be apprehended from the electricity leaving the wire and striking a person on the road is small. Electricity of sufficient intensity to strike a person at the distance of twenty feet from a perfectly insulated wire would in preference be conducted down the nearest pole. It will, however, in all cases, be most prudent to keep at a proper distance from the wire during the existence of a thunder-storm, or even at any time when the sound of thunder is heard in the distance.

In case of wires passing through cities and attached to houses, they should be provided at numerous points with electrical conductors to carry off the discharge to the earth. These consist of copper wires intimately connected with the earth by means of a plate of metal at the lower end, extending up the pole or side of the house, and terminating in a flat plate above, parallel to another plate of metal depending from the wire of the telegraph. The two plates are separated by a thin stratum of air, or some other non-conducting material, through which the intense discharge from the clouds will readily pass and be conducted to the earth, while the insulation of the wire for the purposes of the telegraph is unimpaired.

There are other electrical phenomena connected with the telegraph which, though frequently annoying to the operator, are not attended with the same degree of danger to his person. These are immediately referable to induction at a distance, and consist entirely in the disturbance of the natural electricity of the wire. Suppose a thunder cloud to be driven by the wind in such a direction as to cross, for example, at right angles, the middle of a long line of telegraph wire. During the whole time the cloud is approaching the point of its path directly above the wire, the repulsion of the redundant electricity of the former will constantly drive the natural electricity of the latter further and further along the line, so that, during the approach of the cloud, a continuous current will exist in each half of the line. When the center of action of the cloud arrives at the nearest point of the wire the current will cease for a moment, and as the repulsion gradually diminishes by the receding of the cloud, the natural electricity of the wire will return to its normal condition by a current opposite to that which was first manifested. Since the thunder clouds over the greater portion of the United States move from west to east, lines in a north and south direction are more liable to currents of this class, which may be denominated those of statical induction.

There is another class of currents which, although they continue but for an instant, are more intense than the preceding, giving rise to vivid sparks, and are due to the dynamic induction at a distance of a discharge from a cloud to a cloud, or from a cloud obliquely to the earth.



The greatest intensity is produced when the path of the lightning is parallel to the line of the telegraph, and, in this case, under favorable circumstances sparks and shocks may result from a discharge between two clouds at the distance of several miles. In these inductive actions there is no transfer of the electricity from the cloud to the wire, but simply the disturbance of the natural electricity of the conductor by the repulsive energy exerted at a distance. As we have said before, nothing screens this induction, for, like magnetism and gravitation, it acts freely through the roof of a house, the air, and all other non-conducting materials, as it probably would do through void space. A similar result is produced on the long lines of railway, and sparks have been observed at the joining of the rails not in perfect metallic connection, particularly at the turn-tables.

The electrical telegraph is sometimes disturbed by other influences. It is evident from what we have said in reference to elevated bodies, that if a line of wire extends over a high hill, the intensity of electricity will be greater at the high points than below, particularly during the occurrence of fogs; the wire will tend to absorb the electricity of the air, and transmit it from the higher to the lower portions; also during the fall of rain and snow on one portion of a long wire, while clear weather exists at another, there would be a current of electricity observed in the intermediate portion. During very warm weather a feeble current is observed at different periods of the day, which may be referred to thermo-electricity. It is well known that when one end of a long conductor is heated and the other cooled, a current of electricity will pass from the hotter to the colder extremity, and this will be continued as long as the difference of temperature exists. Extended lines in a north and south direction are most favorably situated for observing a current of this class. Currents of electricity have also been observed in connection with the appearance of the aurora borealis, of sufficient intensity to set fire to pieces of paper. But the consideration of these will be postponed for another article.

### MEANS OF PROTECTING BUILDINGS.

Although there has been much written and said in disparagement of the admirable invention of our illustrious countryman, Franklin, yet an attentive consideration of all the facts, even independent of theory, fully establishes its great importance.

1st. It is well known, from general experience, that lightning directs itself to the most elevated portions of edifices. Cotton Mather declares that lightning is under the immediate direction of the "Prince of the power of the air," because church steeples are more frequently struck than any other objects. It is therefore evident that the preservative means, whatever they may be, should be applied to the upper portions of a building.

2d. If other conditions be the same, lightning directs itself in preference to metals. When, therefore, a mass of metal occupies the more elevated portion of a house, we may be nearly certain that lightning, if it falls upon the building, will strike that point.

3d. Lightning, when it enters a metallic mass, does mischief only when it quits the metal, and in the vicinity of the point at which it issues. A house, therefore, entirely covered with metal, would be safe, provided this covering were intimately connected with the ground, or if the roof be covered with metal, and this is intimately connected with the ground by metallic conductors of sufficient size, the lightning which may fall on the metallic covering will descend to the ground, which itself is a good conductor, provided it is saturated with water. When there are upon the roof, or in any of the upper stories of an edifice, several distinct metallic masses, completely separated from each other, it will be difficult to tell which of them will be struck in preference. The safest practice is to unite all these masses by rods or bands of iron, copper, or other metal, so that each of them may be in metallic communication with a rod, which may transmit the lightning to the damp earth.

"We thus deduce, from facts established by observation alone, without borrowing anything from theory," says Arago, "a simple, uniform, and rational means of protecting buildings from the effects of lightning. But when we refer, in addition to these facts, to the precise principles or laws of electrical action, as deduced from cautious and refined experiments in the laboratory, we are enabled to give rules for the protection of buildings which, when properly observed, reduce almost to insignificance the danger to be apprehended from the ordinary occurrences connected with the terrific exhibitions of thunder-storms."

From what we have said in regard to the principles of induction, and also in reference to the fact of the negative condition of the earth, it will readily be perceived that the upper end of an elevated conductor must become highly negative under the repulsive energy of a positive cloud, and though it may not be sufficient in itself to cause a rupture of the thick stratum of air intervening between the cloud and the earth, yet if a discharge does take place within the vicinity of this body, it will be drawn toward it, and if the conductor extends to the earth, and is in intimate connection with the damp ground, the discharge will pass innoxiously into the great reservoir. We further know, from theory as well as experiment and observation, that the intensity of attraction is increased when the conductor is terminated above in a single sharp point. Although the attraction at a distance may be greater on a metallic globe of a few feet in diameter than on a metallic point, since the former is able to receive a greater amount of induced charge, which, by the well known law of attraction, will act as if the whole were concentrated at the center of the sphere, yet the intensity of action of the point, and its tendency to open a passage through the air is so great, that it is preferred in protecting a given circumscribed space from lightning.

The question has been agitated, whether one point or a number on the same stem are to be preferred? But this question may be readily settled, provided the reason for preferring a point to a ball or a globe is legitimate, since the surface of a ball itself may be considered as made up of an infinite number of points, and therefore a number of points close together must react upon each other, and thus approximate in result the effect of a continuous spherical surface. In the case of three points on the same stem, the whole amount of inductive effect which is produced in the rod is, as it were, divided into three parts, and is, therefore, less concentrated than in the case of one point; and although at a distance the effect of the three may be equally energetic, yet the one point tends more effectually to rupture the air, and open, as it were, a passage for the discharge from the cloud.



In reference to the subject of the termination of rods by balls or points, much discussion took place in the early introduction of the invention of Franklin, and the subject was elucidated by a very ingenious experiment made by Beccaria, in 1763, which is quoted by Arago. On the roof of a church at Turin this eminent electrician erected a rod of iron insulated on one of the flying buttresses. The upper part of this rod, which was terminated by a single metallic point, was hinged a few inches below the top, so that merely by pulling a string the point could be directed horizontally, upwards or downwards. When the point was pulled downwards during the presence of a thunder cloud in the zenith, the lower end of the rod gave no sparks; but when the point was suddenly directed upward, in a few moments sparks appeared. When the point was downwards, the rod presented a blunt termination toward the sky; when upwards, a sharp point. It might be well to repeat this experiment with some slight variation in the apparatus, in order to establish or disprove, by direct observation, the inference from theory that a single point acts more energetically than three or four points, terminating the same rod. The substance which terminates the conductor should be such as to preserve its form when subjected to the action of the weather, and be infusible by a stroke of lightning. The first requisite is found in the tip of an iron rod gilded, to prevent its becoming blunted by rust; but a point of this kind, though it may protect a building from the first discharge which strikes it, will be melted, and the intensity of its action thereby diminished in the case of a subsequent explosion. We now usually employ for terminating the lightning-rod, a small cone of platinum attached to a copper socket which fits on the top of the rod, made conical for that purpose. Tips of this kind are now generally offered for sale in the large cities. The quantity of platinum on them, however, is generally too small, since we have known them in several instances to be fused by a discharge of lightning. The point itself should be the apex of a solid cone of platinum, or of a thick plate of that metal, fastened by screwing or soldering to the copper socket.

We frequently see announcements in the papers of great improvements in lightning-rods, for which patents have been obtained, and among these boasted improvements have been the application of magnetized steel points to receive the lightning; but this invention, like most of the others which have been given to the public for the same purpose, is the result of some vague analogy or sheer charlatanism. It rests upon no foundation of observation, experiment, or theory. The magnetization of a bar, so far as it has any effect, tends to cause the electrical discharge to revolve around it, and to render the iron very slightly, if anything, a less perfect conductor.

The distance from a rod measured horizontally to which the protecting influence extends, is a question of considerable importance. It has generally been admitted that the point of a lightning-conductor protects a horizontal circular space with a radius equal to twice its own height; that is, if the elevation of a rod above a flat roof be ten feet, it will protect a circular space of twenty feet radius, or forty feet diameter. But this rule cannot always be depended upon; for although it may be true in regard to buildings of stone or brick, with an ordinary sloping roof covered with tiles or slate, it would scarcely hold good if considerable masses of metal formed part of the building or the roof. Observations have been recorded of parts of houses being struck within the limit we have mentioned as that of protection; but there are scarcely any of them satisfactory in determining the point, since it appears from the evidence that in several cases there were separate masses of metal which formed, as it were, independent conductors, and in the other cases there was no evidence that the rod was in proper connection with the earth. In order to protect an extensive building, it will evidently be necessary to arm it with several lightning-conductors, and the less their height, the more they must be multiplied.

In the case of a high steeple, it may be well to establish points at different elevations, by branches from the main rod; for if it be true that the rod merely attracts the lightning which has been determined by the earth itself, or some material under the ground, the discharge, in its passage along the line of least resistance to the point at which it was aimed, may not be made to deviate from its direct course by the attraction of the distant elevated point, and will strike a lower portion of the building. Suppose, for example, a thunder cloud is on the west side of a high steeple, and the point of attraction, which may be damp earth, a pool of water, or other conducting material on the surface or under the ground, at the east end of the church. The discharge from the cloud, in its passage to the point of attraction, may strike a lower portion of the building, the action of the elevated point not being sufficient to deflect it from its course. This inference is in accordance with actual observation. Mr. Alexander Small wrote to Franklin from London, in 1764, that he had seen, in front of his window, a very vivid and slender lightning discharge moving low down, without a zig-zag appearance, and strike a steeple below its summit.

It becomes a matter of interest to ascertain whether the action of an assemblage of conductors, such as is usually found in cities, produces any sensible effect in diminishing the electrical intensity of the cloud, or, in other words, whether their united influence produces any sensible diminution of the destructive effects of thunder storms. Late researches have shown that comparatively but a small amount of development of electricity is sufficient to produce great mechanical effects. Faraday has even asserted that the quantity of electricity necessary to decompose a single grain of water, and consequently the electricity which would be evolved by the decomposition of the same element, would be sufficient to charge a thunder cloud, provided the fluid existed in the free state in which it is found at the surface of charged conductors. A similar inference may be drawn from the great amount of electricity developed by the friction of the small quantity of water existing in steam, as the latter issues through an orifice connected with the side of the boiler. We also find that an iron rod of three fourths of an inch in diameter, is of sufficient size to transmit to the earth without any danger to surrounding objects, a discharge from the clouds, which may be attended with a deafening explosion, and with a jar of thunder powerful enough to shake the building to its foundation.



The intrepid physicist, De Raumer sent a kite up into the air to the height of 400 or 500 feet, in the cord of which was inserted a fine wire of metal. During a thunder storm, he drew from the lower extremity of the cord not mere sparks, but discharges of nine or ten feet long and an inch broad. Beccaria erected a lightning-rod which was separated in the middle by an opening, the upper part being entirely insulated. During thunder storms intense discharges darted incessantly through the opening. So constant were these, that neither the eye nor the ear was hardly able to perceive the intermission.

No physicist, says Arago, will contradict me when I say that each spark taken singly, would have given a shock attended with pain, that ten sparks would have numbed a man's arm, and a hundred proved fatal. Now a hundred sparks passed in less than ten seconds, and hence in every ten seconds, there was drawn from the cloud, a quantity of fulminating matter sufficient to kill a man, and six times as much in every minute. Arago calculates in this way that all the lightning conductors of the building in which the experiment was tried, took from the clouds as much lightning as would have been sufficient in the short space of an hour, to kill upwards of three thousand men. From the foregoing facts and conclusions, we may infer that the lightning-rods of a city may have some effect in silently discharging the cloud, and in preventing explosions which would otherwise take place; but we must recollect that on account of the upward rushing of the moist air, the electricity of the cloud is constantly renewed.

We cannot suppose that the sparks observed by Beccaria in his experiment, and the ringing of bells by Franklin, were due entirely to the electricity immediately received from the cloud. By the powerful induction of the redundant electricity of the latter and the negative action of the earth beneath, the natural electricity of the top of the rod, would be forced down into the earth, the point would become intensely negative, and in this condition would draw from the air around streams of electricity, and in this way a large volume of air around the top of the rod would become negatively electrified; and in case a discharge of lightning took place, its first effect would be to neutralize or fill up, as it were, this void of electricity in this large mass of air surrounding and above the top of the rod, before the remainder of the discharge could pass to the earth. The peculiar sound which is heard when a discharge from a thunder cloud is transmitted through a lightning-rod may possibly be attributed to this cause.

The Smithsonian building, situated in the middle of a plain, at a distance from all other edifices, with its high towers, is particularly exposed to discharges of lightning, and we have reason to believe that in as many as four instances within the last ten years, the lightning has fallen upon the rods and been transmitted innoxiously to the ground.

In two of the instances the lightning was seen to strike the rod on one of the towers; in a third, a bright spark due to induction and attended with an explosion as loud as that of a pistol was perceived; and in the fourth instance, although the platinum top of the rod, which was one hundred and fifty feet from the surface of the ground, was melted, the discharge was transmitted to the earth without any other effort than a slight inductive shock given to a number of persons standing at the foot of the tower. In three of the cases, the peculiar sound we have mentioned was observed; first, a slight hissing noise, and afterwards the loud explosion, as if the former were produced by the effect of the discharge on the air in the immediate vicinity of the rod, and the loud noise from that on the air at a more distant point of its path.

The writer of this article was led to reflect upon this effect of the rod, by a remarkable exhibition he witnessed during a thunder storm at night in 1856. He was in his office, which is in the second story of the main tower of the Smithsonian edifice, when a noise above, as if one of the windows of the tower had been blown in, attracted his attention; an assistant, who was present, was requested to take his lantern and ascertain what had happened. After an absence of some time he returned, saying he could discover nothing to account for the noise, but that he had heard a remarkable hissing sound. The writer then ascended to the top of the tower, and stood in the open trap-door with his head projecting above the flat roof within about twelve feet of the point of the lightning-rod. No rain was falling, though an intensely black cloud was immediately overhead and apparently at a small elevation; from different parts of this lightning was continually flashing, indeed the air around the top of the tower itself appeared to be luminous. But the most remarkable appearance was a stream of light three or four feet long issuing with a loud hissing noise from the top of the lightning-rod. It varied in intensity with each flash, and was almost continuous during the observation. Although the whole appearance was highly interesting, and produced a considerable degree of excitement, yet the writer did not deem it prudent to expose himself to the direct or even inductive effect of a discharge under such conditions, thinking, as he did, with Arago, that however our vanity might prompt us to boast of the acquaintance of some great lords of creation, it is not always desirable to seek their presence or court much familiarity with them. The effect in this case of the rod on the surrounding air and on the cloud itself by invisible induction must have been considerable.

### ACTION OF LIGHTNING-RODS.

The question as to whether the lightning-rod actually attracts the electricity from a distance has been frequently discussed. It will be found, says Sir W. Snow Harris, "that the action of a pointed conductor is purely passive. It is rather the patient than the agent; and such conductors can no more be said to attract or invite a discharge of lightning than a water-course can be said to attract the water which flows through it at the time of heavy rain." This statement does not, as it appears to us present a proper view of the case. From the



established principles of induction, it must be evident that all things being equal, a pointed rod, though elevated but a few feet above the ground, would be struck in preference to any point on the surface, and the propositions as to the space which can be protected from a discharge of lightning is founded on the supposition that the direction of the discharge can be changed by the action of the rod at a distance, and the bolt drawn to itself. The true state of the case appears to us to be as follows:

1st. An elevated pointed rod, erected for example on a high steeple, by its powerful induction diminishes the intensity of the lower part of the cloud, and therefore may lessen the number of explosive discharges to the earth.

2d. If an explosive discharge takes place from the cloud due to any cause whatever, it will be attracted from a given distance around to the rod, and transmitted innoxiously to the earth.

A too exclusive attention to either one or other of these actions has led to imperfect views as regards the office of the lightning-rod. On the one hand, some have considered the whole effect of the rod is to lessen the number of discharges in the way we have described, and have considered it impossible that an explosive discharge could take place on a pointed conductor. But this is not the case, as was shown by Mr. Wilson many years ago by his experiments in London. It is true, that when a needle is presented to a charged conductor, the electricity is drawn off silently without an explosion, and this is always the case if sufficient time be allowed for the electricity to escape in this way. But if the point be suddenly brought within striking distance of the conductor by a rapid motion, such as would be produced by the movement of a horizontal arm carrying the point immediately under the conductor in an instant, an explosive discharge will take place. In this case, sufficient time is not given for the slower transmission of the electricity by what has been denominated the glowing discharge, and a rupture of the air is produced as in the action of a conductor terminated by a ball.

It would follow from this, that, in case of a rapidly-moving cloud across the zenith of a rod, there would be a greater tendency to an explosive discharge on the point than when the cloud was nearly stationary. For a similar reason, if a point, connected by a wire with the earth, be directed toward an insulated conductor, and the latter be suddenly electrified by a discharge from a second conductor, an explosion will take place between the first conductor and the point. A similar effect would be produced if a lower cloud received a sudden discharge from one above it, a case which probably frequently occurs in nature. Mr. Wise informs us that, when a discharge takes place beneath a cloud to the earth, a discharge is seen to pass between the upper and lower part of the cloud, represented by Fig. 19. We are warranted from the foregoing facts, as well as from the numerous examples in which lightning has actually beeen seen to fall upon pointed rods explosively, and the number of points which have been melted, to conclude that the rod, under certain conditions, does actually attract the lightning, though when properly constructed it transmits it without accident to the earth.